Chapter 3
The End of Epicurean Infinity: Critical Reflections on the Epicurean Infinite Universe

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Abstract In contrast to other ancient philosophers, Epicurus and his followers famously maintained the infinity of matter, and consequently of worlds. This was inferred from the infinity of space, because they believed that a limited amount of matter would inevitably be scattered through infinite space, and hence be unable to meet and form stable compounds. By contrast, the Stoics claimed that there was only a finite amount of matter in infinite space, which stayed together because of a general centripetal tendency. The Roman Epicurean poet Lucretius tried to defend the Epicurean conception of infinity against this Stoic alternative view, but not very convincingly. One might suspect, therefore, that the Epicureans' adherence to the infinity of matter was not so much dictated by physical arguments as it was motivated by other, mostly theological and ethical, concerns. More specifically, the infinity of atoms and worlds was used as a premise in several arguments against divine intervention in the universe. The infinity of worlds was claimed to rule out divine intervention directly, while the infinity of atoms lent plausibility to the chance formation of worlds. Moreover, the infinity of atoms and worlds was used to ensure the truth of multiple explanations, which was presented by Epicurus as the only way to ward off divine intervention in the realm of celestial phenomena. However, it will be argued that in all of these arguments the infinity of matter is either unnecessary or insufficient for reaching the desired conclusion.

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3.1 Introduction

A prominent feature of ancient atomism that still captures the imagination is its endorsement of the infinity of the universe and, associated with it, the infinite number of worlds.[1] Whereas most ancient philosophers argued for a single cosmos, either identified with a finite universe, as in Plato's and Aristotle's cosmologies, or placed in an infinite void, as in Stoic cosmology, the atomists made our cosmos a negligible and utterly unremarkable part of the infinite matter-filled universe.[2]

The infinity of the universe, in terms of space as well as bodies, was arrived at through rigorous argumentation, much of which may go back to the earlier atomists, but which has come down to us mainly through the works of Epicurus and Lucretius, who adopted and reinforced some of the earlier arguments.[3] The centrality of this theory to Epicurean cosmology is clear from the prominent place given to it in Epicurus' *Letter to Herodotus* (close to the beginning) and in Lucretius' *De rerum natura* (in the final and concluding parts of books one and two).

However, the dual infinity of matter and void, and the consequent infinite number of worlds, are not simply curious but otherwise sterile logical consequences of the basic tenets of Epicurean physics, but they also serve as the starting points for further inferences: the infinity of the universe is argued to rule out divine governance, to make the spontaneous formation of a cosmos not merely possible but inevitable, and to guarantee the simultaneous truth of multiple, mutually incompatible explanations. Moreover, all of these consequences relate directly or indirectly to the question of the gods' involvement in the world.

In this chapter I will investigate the infinity of the universe from both points of view. First, I will critically examine the Epicurean arguments for the infinity of space and bodies, as well as the way in which they deal with a rival view, and, second, I will look into some of the corollaries to the infinity of space and bodies, and the role these corollaries play in underpinning the Epicurean view of the gods, in order to see whether this role may serve as an additional motivation for the Epicureans' insistence on the infinity of bodies and worlds.

[1] See e.g. Mash 1993, 204–210; Dick 1996, 12–13, Dowd 2015, 56, Traphagan 2015, 18; and Darling 2016, s.vv. 'atomism,' 'Leucippus,' 'Democritus,' 'Metrodorus,' 'Epicurus' and 'Lucretius.'

[2] See e.g. Lucretius 6.649–652. Henceforth all references to Lucretius will follow the text and translation of Rouse and Smith 1992, unless otherwise specified.

[3] For the Presocratic antecedents of these arguments see Furley 1989, 110–114; Avotins 1983; Asmis 1984, 261–267.

3.2 Cosmological Arguments for the Infinity of the Universe

Two Epicurean accounts for the infinity of the universe have come down to us. One is found in Epicurus' *Letter to Herodotus* 41–42, and another, longer one in Lucretius' *De rerum natura* 1.951–1113. In both accounts the arguments presuppose the Epicurean division of being into bodies and void. In order to clarify these two somewhat ambiguous concepts and to provide a background for the discussion of Epicurean infinity, I will start with a brief discussion of these two concepts.

3.2.1 Clarification of Concepts: Bodies and Void

According to Epicurus the universe (τὸ πᾶν) consists of bodies and void (κενόν).[4] The existence of bodies is directly attested by the evidence of the senses,[5] but the existence of void, being inaccessible to sense perception, has to be inferred from other phenomena (*Letter to Herodotus* 40):

> And if there were not that which we term void and room and intangible nature, bodies would have nowhere to exist and nothing through which to move, as they are seen to move.[6]

In this statement *void* (κενόν) is connected with two other spatial concepts, *room* (χώρα) and *intangible nature* (ἀναφὴς φύσις). In the *Letter to Herodotus* Epicurus does not provide a definition for any of these three terms, but a later source, Sextus Empiricus, *Against the Professors* 10.2, provides the following testimony:

> According to Epicurus, of 'intangible nature,' as he calls it, one kind is named 'void,' another 'place,' and another 'room,' the names varying according to the different ways of looking at it, since the same nature when empty of all body is called 'void,' when occupied by a body is named 'place,' and when bodies roam through it becomes 'room.'[7]

So, although Epicurus apparently did sometimes distinguish these spatial terms, in *Letter to Herodotus* 40 these distinctions are observed neither nominally – for Epicurus presents the three terms as mere synonyms –,[8] nor conceptually – for the

[4] Epicurus, *Letter to Herodotus* 39. Henceforth all references to Epicurus' letters will follow the text edition of Arrighetti 1973. See also Lucretius 1.419–20.

[5] Epicurus, *Letter to Herodotus* 39. See also Lucretius 1.422–25.

[6] Epicurus, *Letter to Herodotus* 40: εἰ <δὲ> μὴ ἦν ὃ κενὸν καὶ χώραν καὶ ἀναφῆ φύσιν ὀνομάζομεν, οὐκ ἂν εἶχε τὰ σώματα ὅπου ἦν οὐδὲ δι' οὗ ἐκινεῖτο, καθάπερ φαίνεται κινούμενα. Translation in Bailey 1926, 23 (slightly modified). See also Lucretius 1.329–69.

[7] Sextus Empiricus, *Against the Professors* 10.2: κατὰ τὸν Ἐπίκουρον τῆς ἀναφοῦς καλουμένης φύσεως τὸ μέν τι ὀνομάζεται κενόν, τὸ δὲ τόπος, τὸ δὲ χώρα, μεταλαμβανομένων κατὰ διαφόρους ἐπιβολὰς τῶν ὀνομάτων, ἐπείπερ ἡ αὐτὴ φύσις ἔρημος μὲν καθεστηκυῖα παντὸς σώματος κενὸν προσαγορεύεται, καταλαμβανομένη δὲ ὑπὸ σώματος τόπος καλεῖται, χωρούντων δὲ δι' αὐτῆς σωμάτων χώρα γίνεται. Text in Long and Sedley 1987b, 22; translation in Long and Sedley 1987a, 28 (slightly modified).

[8] Similarly Lucretius 1.334 "quapropter locus est intactus inane vacansque;" 1.954-955 "quod inane repertumst / seu locus ac spatium;" and 1.1074 "omnis enim locus ac spatium, quod in<ane vocamus>."

existence of void is inferred from the fact that bodies (1) need to be somewhere, which is place, and (2) need something to move through, which is room. This means that in *Letter to Herodotus* 40, and possibly also other passages, the term 'void' is used to denote not just empty space, but also occupied space (i.e. 'place') and the space through which bodies move (i.e. 'room'). In other words, 'void' is used as a stand-in for the generic term 'intangible nature,' which may also be translated as 'space.'[9]

Another ambiguity that must be addressed concerns the concept of body. Bodies, according to Epicurus (*Letter to Herodotus* 40–41), come in two kinds: compounds and atoms. Now, when Epicurus claims that the existence of bodies is attested by the evidence of the senses (see above), he must be thinking primarily of compounds, since atoms cannot be perceived (*Letter to Herodotus* 56). However, since in compound bodies there is always an admixture of void (Lucretius 1.358-369), conceptual purity requires that, in those contexts where bodies are opposed to void, we think primarily of atoms.

3.2.2 *Positive Arguments for the Infinity of the Universe, Bodies and Void*

In section 41 of his *Letter to Herodotus*, Epicurus provides the following argument for the infinity of the universe:

> Moreover, the universe is boundless. For that which is bounded has an extreme point, and the extreme point is seen against something else, <but the universe is not seen against something else,>[10] so that, as it has no extreme point, it has no limit, and as it has no limit, it must be boundless and not bounded.[11]

The same view is also defended by Lucretius (1.951-1007), who offers no fewer than four arguments.[12] In the first place (1.958-967), Lucretius argues, whatever is finite must have a boundary, but a boundary requires something external to bound it; however, since there is nothing external to the universe, the universe cannot have a

[9] See Long and Sedley 1987a, 29–30; Algra 1995, 52–58. However, Inwood 1981, and more recently Konstan 2014, claim that Epicurus uses the term 'void' (τὸ κενόν) exclusively to refer to '*empty* space.' (Concerning these two interpretations see also n18 below.) In this article I will follow the first-mentioned interpretation, which I find to be the more convincing of the two. My own conclusions concerning the Epicurean theory of infinity do not, however, essentially depend on this choice, and could also agree with the alternative interpretation.

[10] Addition suggested by Usener 1887, xviii, on the basis of Cicero's version of Epicurus' argument in *De divinatione* 2.103; it is rejected by Bailey 1926, 22 and 184, but accepted by Arrighetti 1973, 39.

[11] Epicurus, *Letter to Herodotus* 41: Ἀλλὰ μὴν καὶ τὸ πᾶν ἄπειρόν ἐστι· τὸ γὰρ πεπερασμένον ἄκρον ἔχει· τὸ δὲ ἄκρον παρ' ἕτερόν τι θεωρεῖται· <Ἀλλὰ μὴν τὸ πᾶν οὐ παρ' ἕτερόν τι θεωρεῖται·> ὥστε οὐκ ἔχον ἄκρον πέρας οὐκ ἔχει· πέρας δὲ οὐκ ἔχον ἄπειρον ἂν εἴη καὶ οὐ πεπερασμένον. Translation in Bailey 1926, 23 (modified).

[12] See Bailey 1947, vol. 2, 763–764; Asmis 1984, 262–264; Bakker 2016, 182–184.

boundary, and hence must be infinite. Secondly (1.968-983), if the universe had a boundary and someone threw a spear towards it, the spear would either stop or continue: if it stops, there must be matter outside to obstruct it, but if it continues there must be empty space to receive it: in either case there must be something outside, and the boundary of the universe turns out to be no boundary at all; this result repeats itself wherever one assumes the presence of a boundary. As a consequence the universe cannot have a boundary, and is proved to be infinite. Thirdly (1.984-997), if space were finite and bounded on all sides, all bodies would be heaped up at the 'bottom,' i.e. the lower boundary, by strength of their weight, and nothing further would happen, but this is not the case; therefore the universe must be infinite. Finally (1.998-1001), we see that everything that is bounded is always bounded by something else, but in the case of the universe there is nothing else to bound it; therefore the universe must be infinite.

The first of Lucretius' arguments basically repeats Epicurus' argument from the *Letter to Herodotus* 41, and may go back to the earlier atomists: one version is presented and rejected by Aristotle in *Physics* 3.4, 203b20-22. The second argument is a famous thought experiment that goes back to the Pythagorean Archytas and was also used by the Stoics.[13] Both these arguments, as well as the fourth, exploit the notion of limit, which seems to include the notion of a 'beyond.'[14] Lucretius' third argument is of a different nature. Presupposing the Epicurean conception of downward motion as a motion along parallel lines from infinity to infinity,[15] and hypothetically enclosing the universe in boundaries, Lucretius argues that the lower boundary, the 'bottom,' would obstruct this natural downward motion and cause matter to be compacted into one inert mass.[16] However, at this point of the argument the Epicurean theory of parallel downward motion has not yet been proved: in fact, its proof depends upon the rejection of centripetal gravity in 1.1052-1093 (see the next section), which in turn presupposes the infinity of space – the very thing Lucretius is arguing for here. In short: Lucretius' third argument presents a *petitio principii*. The fourth argument seems to be nothing but a restatement of the first. A version of this argument is also used by the Stoic Cleomedes (1.1, 112–122).

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[13] Archytas fr. A24 in Diels and Kranz 1951–1952; Stoics *SVF* II 535–536 (Here and elsewhere I use the standard abbreviation *SVF* for references to Arnim 1903–1905). For an analysis of the various ancient versions of this thought experiment, see Ierodiakonou 2011. For early modern versions of the thought experiment see Granada's and Palmerino's Chapters 8 and 12 in this volume.

[14] Furley 1989, 111; Avotins 1983, 427; Asmis 1984, 262–263.

[15] See Epicurus, *Letter to Herodotus* 60, with the comments on the same in Konstan 1972, and Lucretius 2.216-250, with the comments on the same in Bakker 2016, 214–216.

[16] It might be argued that, were the existence of a centripetal downward motion assumed, the centre would provide a similar 'bottom,' and the same argument would apply (on which see p. 51 below). However, in the present context Lucretius is clearly thinking of external boundaries, and his identification of one of these external boundaries as the 'bottom' indicates that he is assuming the existence of a parallel downward motion.

With the infinity of the universe proven, and given the fact that the universe consists of bodies and void, the question naturally arises how the infinity of the universe relates to each of its two components. In sections 41–42 of the *Letter to Herodotus*, Epicurus argues for the infinity of both bodies and void:

> Furthermore, the universe is boundless both in the number of the bodies and in the extent of the void. For if on the one hand the void were boundless, and the bodies limited in number, the bodies could not stay anywhere, but would be carried about and scattered through the infinite void, not having other bodies to support them and keep them in place by means of collisions. But if, on the other hand, the void were limited, the infinite bodies would not have a place to be in.[17]

Here too, 'void' seems to be used in the sense of 'space,' encompassing both that through which bodies move (i.e. 'room') and that where bodies are (i.e. 'place').[18] However, this should not mislead us into thinking that bodies and space might be coextensive, with bodies (i.e. atoms) filling up every portion of space. Lucretius offers three arguments for the existence of actually empty space. Firstly, motion requires the existence of pockets of empty space, in order to provide a beginning of motion (1.335-345); secondly, the penetration of sound and cold into bodies, but also the dispersion of food through the living body require the existence of empty passageways (1.346-357), and thirdly, differences in specific weight must be due to differing amounts of empty space in (compound) bodies (1.358-369).[19] When, therefore, the Epicureans state that both the extent of space and the number of bodies are infinite, what they have in mind is an infinite alternation of (atomic) bodies and (empty) space.[20] In an expanded version of Epicurus' argument for the infinite number of bodies Lucretius (1.1008-1051) specifies that our world is being maintained by external bodies, which constantly either replace atoms or beat them back into line.[21]

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[17] Epicurus, *Letter to Herodotus* 41–42: Καὶ μὴν καὶ τῷ πλήθει τῶν σωμάτων ἄπειρόν ἐστι τὸ πᾶν καὶ τῷ μεγέθει τοῦ κενοῦ· εἴ τε γὰρ ἦν τὸ κενὸν ἄπειρον, τὰ δὲ σώματα ὡρισμένα, οὐθαμοῦ ἂν ἔμενε τὰ σώματα, Ἀλλ' ἐφέρετο κατὰ τὸ ἄπειρον κενὸν διεσπαρμένα, οὐκ ἔχοντα τὰ ὑπερείδοντα καὶ στέλλοντα κατὰ τὰς Ἀνακοπάς· εἴ τε τὸ κενὸν ἦν ὡρισμένον, οὐκ ἂν εἶχε τὰ ἄπειρα σώματα ὅπου ἐνέστη. Translation in Bailey 1926, 23 (slightly modified).

[18] According to Algra 1995, 56–57, 'being in' and 'moving through' imply that 'void' is here thought of as occupied, and therefore not empty. Konstan 2014, 90–91, retorts that 'being in' means 'being surrounded by' and 'being separated by,' and since bodies are always surrounded and separated by empty space (because otherwise they would not be able to move), the infinity of bodies implies an infinite amount of surrounding empty space.

[19] Algra 1995, 57.

[20] Cf. Lucretius 1.1008-1011 "Ipsa modum porro sibi rerum summa parare / ne possit, natura tenet, quae corpus inani / et quod inane autem est finiri corpore cogit, / ut sic alternis infinita omnia reddat." Text from Rouse and Smith 1992, 82 and 84.

[21] A similar argument is also found in fragment 67 (in Smith 1993, 259–260) of the Epicurean inscription of Diogenes of Oenoanda.

3.2.3 Refutation of a Rival Theory

At first sight the Epicurean argument for an infinite number of bodies seems quite plausible. However, the assumption it is based on – that in infinite space a limited number of bodies would not be able to find a stable foothold, and would therefore be dispersed throughout the void – is not self-evident. While Epicurus simply assumes that this is true, Lucretius is aware of, and actively engages with, a rival theory that challenges precisely this implication. In 1.1052-1093, Lucretius warns Memmius, his addressee, to "avoid and keep afar" the view

> that, as some say, all things press towards the centre of the whole and that for this reason the nature of the world stands firm without any external blows, and […] cannot be set loose in any direction, because all presses towards the centre.[22]

If, as these unnamed rivals claim, all bodies have a natural tendency to move towards a central point, even a limited amount of bodies would be able to remain together and be safe from dispersal into the infinite void, without the need for external blows to keep the bodies in check, or to repair the losses. One could even argue – although Lucretius does not make this point – that the assumption of a general centripetal tendency of bodies would actually preclude their infinite number, because otherwise the world would experience continuous growth due to the incessant accrual of new atoms converging on the centre from the infinite stock of surrounding matter, which is not the case.[23]

Lucretius does not identify the proponents of this theory, and over the years various candidates have been proposed. The common, and in my opinion the most plausible, view is that Lucretius was thinking of the Stoics.[24] Although several ancient philosophers and schools of philosophy endorsed some kind of centripetal gravity, only the Stoics deployed this theory in order to safeguard the integrity of a single and finite cosmos in infinite space, and only they extended this centripetal tendency to all bodies, heavy and light alike. Other proposed candidates, like Aristotle or the early Platonists, simply rejected extra-cosmic space, and therefore did not have to account for the coherence of the cosmos as such, or to counterbalance the centrifugal tendency of air and fire with a centripetal one.[25] However, although Lucretius probably had the Stoics in mind, this does not necessarily mean that he understood

[22] Lucretius 1.1052–1055: "Illud in his rebus longe fuge credere, Memmi, / in medium summae quod dicunt omnia niti, / atque ideo mundi naturam stare sine ullis / ictibus externis, neque quoquam posse resolvi, / […] quod in medium sint omnia nixa." Text and translation from Rouse and Smith 1992, 87–89.

[23] Compare Aristotle, *De caelo* 1.8, 276a18-b21, where Aristotle argues that, if one assumes the universe to consist of the same elements having the same nature and potentialities everywhere, the universe must also have a single centre towards (or away from, or around) which all the elements would move; hence there can only be one world, because every part of matter in another world would take up position with respect to this single centre.

[24] For a more extended argument see Bakker 2016, 191–202.

[25] Aristotle was proposed by Furley 1989, 187–195, and the early Platonists by Sedley 1998, 78–82.

or represented their theory correctly in every respect. The clearest ancient testimony as to the Stoic theory in question is preserved by Stobaeus:

> In the case of all things in the cosmos that have a *hexis* of their own the parts tend towards the centre of the whole thing. Similarly in the case of the cosmos itself; and it is in virtue of this fact that it is rightly said that all parts of the cosmos have a tendency to move towards the centre of the cosmos, most of all the things possessing weight. The same thing is responsible both for the immobility of the cosmos in the infinite void and for the earth's immobility in the cosmos, as it is situated around the centre of it [viz. of the cosmos] in a state of equal balance. Still it is not unrestrictedly so that body has weight, but air and fire are weightless. However, also these elements tend towards the centre of the whole globe of the cosmos, although they find their relative position in the direction of the periphery of the cosmos. For by their own nature they are upward moving because they don't have any share in weight.[26]

According to the Stoics, just as individual things within the cosmos are held together by a cohesive force or *hexis*, so the cosmos as a whole has a *hexis*, which causes all its parts to converge on its centre. This tendency is felt most strongly by the heaviest parts, which take up a more central position, but less by the weightless bodies, which therefore move towards, and settle at, the periphery.

After describing the rival theory and mockingly highlighting some of its paradoxical corollaries – that on the underside of the earth gravity is directed upwards, and animals and humans stand upside down (1058–1067) – Lucretius proceeds with his refutation. His main arguments are, first (1070–1071), that the universe, being infinite, does not have a centre for the parts of the cosmos to move towards; second (1071–1080), that the centre, even if it existed, would be a spatial and hence incorporeal entity, and as such incapable of exerting any effect on bodies; and, third (1083–1093), that the rival theory is internally inconsistent in also claiming that air and fire tend away from the centre.

Given that the rival theory stands in the way of a central Epicurean tenet, one would expect a particularly strong effort to refute it. In fact, however, Lucretius' arguments seem to be rather weak. In order to demonstrate this I will now discuss Lucretius' arguments one by one. I will start with the first and third arguments, whose inadequacy is the most obvious, and leave the second argument, which presents some difficulties, for last.

Lucretius first argues that there is no centre, because the (infinite) universe can have no centre. This seems to be a good point. However, if we take a closer look at the Stoic theory as reported by Stobaeus (see above) and other sources, we see that

[26] Stobaeus, *Eclogae Physicae* 1.166, 2–22 (= Arius Didymus fr.23 / *SVF* I 99): Τῶν δ' ἐν τῷ κόσμῳ πάντων τῶν κατ' ἰδίαν ἕξιν συνεστώτων τὰ μέρη τὴν φορὰν ἔχειν εἰς τὸ τοῦ ὅλου μέσον, ὁμοίως δὲ καὶ αὐτοῦ τοῦ κόσμου· διόπερ ὀρθῶς λέγεσθαι πάντα τὰ μέρη τοῦ κόσμου ἐπὶ τὸ μέσον τοῦ κόσμου τὴν φορὰν ἔχειν, μάλιστα δὲ τὰ βάρος ἔχοντα. ταὐτὸν δ' αἴτιον εἶναι καὶ τῆς τοῦ κόσμου μονῆς ἐν Ἀπείρῳ κενῷ καὶ τῆς γῆς παραπλησίως ἐν τῷ κόσμῳ, περὶ τὸ τούτου κέντρον καθιδρυμένης ἰσοκρατῶς. οὐ πάντως δὲ σῶμα βάρος ἔχειν, Ἀλλ' Ἀβαρῆ εἶναι Ἀέρα καὶ πῦρ· τείνεσθαι δὲ καὶ ταῦτά πως ἐπὶ τὸ τῆς ὅλης σφαίρας τοῦ κόσμου μέσον, τὴν δὲ σύστασιν πρὸς τὴν περιφέρειαν αὐτοῦ ποιεῖσθαι. φύσει γὰρ Ἀνώφοιτα ταυτ' εἶναι διὰ τὸ μηδενὸς μετέχειν βάρους. Text from Arnim 1903–1905, vol. 1, 27; translation in Algra 1988, 160.

the centre in question is not the centre of the universe at all, but the centre of the (finite) cosmos.[27] Lucretius' first argument, then, simply turns out to be unfounded.

Lucretius' third argument consists in pointing out an internal inconsistency in his rivals' position. In line 1052 Lucretius still reported that, according to the unnamed rivals, '*all* things press towards the centre of the whole' ('in medium summae […] *omnia* niti') (my emphasis). Now, in lines 1083–1084, we are told that according to these same opponents '*not all* bodies press towards the centre' ('*non omnia* corpora […] in medium niti') (my emphasis), but only those which make up earth and water, whereas air and fire are naturally centrifugal.[28] We do not exactly know how the argument was developed because the relevant portion of Lucretius' text is lost in a lacuna, but Bailey's suggestion that Lucretius would have first charged his rivals with inconsistency, and then pointed out that their thesis of centrifugal air and fire undermines the very coherence of the cosmos which their original thesis was meant to safeguard, is quite plausible.[29] However, if we compare Lucretius' criticism with the actual statements of the Stoics, we can see both where it came from, and why it may not be justified. On the one hand, Stobaeus confirms that the Stoics did, in fact, make these two, apparently inconsistent, claims, asserting both that all the elements, including air and fire, show a tendency to move towards the centre, and that air and fire have a natural tendency to move upwards, i.e. away from the centre. On the other hand, however, Stobaeus' testimony also shows that, in reality, these two claims are neither inconsistent with each other nor deserving of Lucretius' criticism, since Stobaeus clearly states that the centrifugal tendency of air and fire is only secondary and subordinate to their centripetal tendency, and will not take them beyond the confines of the cosmos. On the basis of this and other testimonies some commentators ascribe to the Stoics a version of the ancient extrusion or buoyancy theory, according to which lighter bodies, such as those which make up air and fire, have a *natural* tendency to move downwards (i.e. towards the centre), but are extruded and forced upwards (i.e. away from the centre) *against their nature* by heavier ones, and hence they will not move beyond the sphere of these heavier elements, but instead position themselves at the periphery.[30] Whether or not this interpretation is correct, it at least shows that it would be possible to resolve the apparent inconsistency in a way that the Epicureans could hardly object to, since they themselves endorsed a version of the buoyancy theory, albeit one that did not define

[27] See e.g. Plutarch, *De Stoicorum repugnantiis* 44, 1055a 1–2 (*SVF* II 550, 31–32), quoting Chrysippus: πιθανὸν πᾶσι τοῖς σώμασιν εἶναι τὴν πρώτην κατὰ φύσιν κίνησιν πρὸς τὸ τοῦ κόσμου μέσον; and Cleomedes 1.1, 91–92: *νένευκε* γὰρ {sc. ὁ κόσμος} ἐπὶ τὸ ἑαυτοῦ μέσον καὶ τοῦτο ἔχει κάτω, ὅπου *νένευκεν*.

[28] Furley 1989, 189, claims without offering an argument that no such inconsistency is implied: 'omnia' in l. 1052 would refer only to bodies that are heavy, and coming from all sides, while 'omnia corpora' in l. 1083 would refer to all bodies, both heavy and light. Furley's claim is supported by Sedley 1998, 79. See, however, Schmidt 1990, 213, and Bakker 2016, 197.

[29] Bailey 1947, vol. 2, 787–788.

[30] Sambursky 1959, 111; Wolff 1988, 507 *et passim*; Furley 1989, 192–193; idem 1999, 444–445. For arguments against the attribution of this theory to the Stoics see Bakker 2016, 197–198.

upwards and downwards in centrifocal,[31] but in parallel terms. Thus Lucretius' third argument is dissipated, too.

This brings us to Lucretius' second argument. In lines 1.1074-1080 we read:

> For all place and space, which we call void, must yield a passage through middle or not-middle equally to weights, wherever their movements tend. Nor is there any place in which bodies, when they have come thither, can lose the force of weight and stand still in the void; nor again must that which is void ever give support for anything, but, as its nature craves, it must proceed to give place.[32]

Here Lucretius points out that, even if it existed, the centre, being a place and hence incorporeal, would not be able to affect bodies in the way the anonymous rivals want it to. This seems to be a legitimate point.[33] The Stoics indeed held that a centre was a place or a limit, and that places and limits as such were incorporeal.[34] They also held that incorporeal entities were incapable of producing effects in bodies.[35] On these matters Stoics and Epicureans could, in fact, see eye to eye.[36] Consequently, the centre would not be able to attract bodies to itself or to check their motion. Here, too, however, a closer look at our sources reveals that Lucretius may not quite have captured the Stoic theory. Indeed, although the precise interpretation of the relevant testimonies is disputed, it seems clear that the Stoics did not assign some miraculous power of attraction to the centre, but rather considered the centripetal motion to be the resultant effect of a cohesive force that somehow draws all the parts of the cosmos to each other.[37] In other words, the centripetal tendency of bodies is not attributable to the incorporeal centre, but to the corporeal whole to which the

[31] For the buoyancy theory see Epicurus fr. 276 (in Usener 1887, 196–197) and Lucretius 2.184–215, with the comments on the same in Bakker 2016, 211–213. 'Centrifocal' is a term coined by Furley 1989, 15, 234–235, to describe systems in which 'up' and 'down' are defined in relation to a centre; for the contrast between centrifocal and parallel dynamics see Bakker 2016, 177–179.

[32] Lucretius 1.1074–1080: "omnis enim locus ac spatium, quod inane vocamus, / per medium, per non medium, concedere debet / aeque ponderibus, motus quacumque feruntur. / nec quisquam locus est, quo corpora cum venere, / ponderis amissa vi possint stare in inani; / nec quod inane autem est ulli subsistere debet, / quin, sua quod natura petit, concedere pergat." Text and translation from Rouse and Smith 1992, 88–91.

[33] A similar point against the Stoic theory is made by Plutarch in *De facie in orbe lunae* 7, 924b 4–8 and 11, 926a 10 – b 7.

[34] On the centre as a place see Plutarch, *De facie* 6, 923e 5 and 926a 2; on the centre being a limit see ibid. 10, 925e 10–11 and 11, 926b 9 (cf. Aristotle, *De caelo* 2.13, 293a 33). On the incorporeal nature of place see *SVF* II 331; on that of limits see *SVF* II 487 and 488.

[35] *SVF* I 89; II 336, 340, 341, 343, 363, 387: only corporeal things can produce an effect.

[36] On place/space/void being incapable of affecting bodies in Epicurean cosmology see e.g. Lucretius 1.437-439, 443 and 2.235-237. Cf. also Sextus Empiricus, *Against the Professors* 10.221-222 and the scholion to Epicurus, *Letter to Herodotus* 43.

[37] Sambursky 1959, 111–113; Wolff 1988, 505–507; Furley 1989, 8, 192; 1999, 443–448. Another indication that the centripetal tendency was merely a resultant is provided by the later Stoic Cleomedes (1.1, 164–172), who claims that only in spherical bodies the inward tendency of their parts is always directed towards the centre; in oblong bodies, on the other hand, the focus of each part's motion does not necessarily coincide with the centre of the whole.

individual bodies belong, whence it is communicated to the individual bodies themselves.

As a matter of fact, Lucretius even seems to hint at this possibility, perhaps unwittingly, when writing, at 1.1077-1078: "Nor is there any place in which bodies, when they have come thither, can lose the force of weight and stand still in the void." In these lines he seems to envisage, and reject, the thesis that upon reaching the centre bodies would actively lay down their weight and come to a standstill. Although this account comes closer to the Stoics' actual theory, Lucretius' words still betray an Epicurean bias: according to the Stoic theory bodies would stop at the centre not because they lose their weight, but rather because upon reaching the centre their downward or centripetal tendency, which is weight, is fulfilled or actualized. For the Epicureans, on the other hand, downward motion is motion along parallel lines from infinity to infinity, a motion which can neither be 'laid down,' nor be checked by the resistance of some immaterial 'centre.'[38] At this point, however, Lucretius has not yet established the Epicurean theory of weight and downward motion, nor would he have been able to, before the Stoic alternative was fully refuted.

Moreover, it is not clear on what grounds the Stoic theory is rejected. Evidently the Epicureans could not accept the Stoic theory of centripetal gravity *tout court*, as this requires a complete contiguity of bodies – Stoics and Epicureans alike rejected the possibility of action at a distance –[39] that is at odds with the Epicurean duality of atoms and void. Yet there does not seem to be a cogent reason why bodies could not have an *inbuilt* tendency to move towards a specific point. After all, the Epicureans themselves endorsed the view that weight is a tendency to move in a certain direction, albeit a motion along parallel lines, and not along lines converging to a single point.[40]

In reaction against this view Lucretius could have repeated his earlier argument of 1.984-997.[41] There he had argued that if the universe had a bottom, all matter would be heaped up there to form one compact and inert mass, putting an end to all activity and change.[42] Now, on the assumption of a centripetal downward motion, the 'centre' would provide just such a 'bottom,' so that the same conclusion would apply. However, I do not believe such a conclusion would be warranted, as it does not seem to take into account a crucial aspect of the Epicurean theory of atomic motion. According to the Epicureans (including Lucretius) the atoms are in constant motion, and when their motion is checked they will simply rebound and continue to move in the opposite direction[43]: accordingly, even with the assumption of an absolute 'bottom,' no complete cessation of activity and change would result. Anyway, Lucretius does not invoke this argument against the rival theory.

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[38] For the Epicureans' endorsement of a parallel downward motion see n15 above.

[39] For the Stoics see Sambursky 1962, 102–103; Long 1986, 160; Wolff 1988, 507, 522. For the Epicureans see Furley 1989, 12, 78; O'Keefe 2005, 80–81.

[40] See Konstan 2014, 96.

[41] See also Bakker 2016, 208–209.

[42] See p. 45 above.

[43] Epicurus, *Letter to Herodotus* 43–44; idem fr. 280 (in Usener 1887, 199); Lucretius 2.80–88.

What is more, later on in the *De rerum natura*, he seems to actually endorse the centrifocal theory that he just rejected. In 5.449-508 Lucretius describes the coming-into-being of our cosmos in terms that strongly suggest that a centripetal gravity is at work.[44] In lines 449–454, for instance, we read:

> For in plain fact firstly all the bodies of earth, because they were heavy and entangled, came together in the centre and all took the lowest place; and the more entangled they came together, the more they squeezed out those particles which could make sea, stars, sun, and moon and the walls of the great world[.][45]

The entire process starts with earthy particles moving towards, and settling in, the centre, or "the lowest place," "because they were heavy and entangled." As they settle and become even more entangled they squeeze out all the lighter stuffs that will eventually make up the sea, the heavenly bodies and the outer boundary of the cosmos. Later on we learn how in this way ether, which is the lightest element, takes up the highest and outermost region of the cosmos, "fencing in all the rest with greedy embrace,"[46] and how the other elements and the individual heavenly bodies take up intermediate positions in proportion to their relative weights.

Nowhere in this passage we are told *why* heavy bodies should move to the centre; Lucretius simply assumes that they do, as if it were natural for them to do so. However, if heavy bodies naturally move towards the centre, but also by definition tend downwards, then 'to the centre' and 'downwards' must be the same thing, as indeed Lucretius seems to imply, and as was definitely the case in Stoic cosmology.[47] In other words, Lucretius' cosmogony assumes a theory of centripetal gravity that is virtually indistinguishable from the rival theory he rejected earlier.

As it turns out, then, none of Lucretius' three arguments against centripetal gravity seems cogent. Two arguments are simply misguided, while another can be easily circumvented and is, in fact, contradicted by Lucretius himself.

3.2.4 The Status of Lucretius 1.1052-1093 and 5.449-508

In the preceding section we encountered two mutually inconsistent Lucretian passages. In the first of these (1.1052-1093) Lucretius refutes a rival theory that may be attributed to the Stoics. Now, since it is generally assumed that Epicurus himself did not yet engage the Stoics, who had then only recently come into the picture,

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[44] For a more extensive discussion of this passage see Bakker 2016, 223–235.

[45] Lucretius 5.449–454: "Quippe etenim primum terrai corpora quaeque, / propterea quod erant gravia et perplexa, coibant / in medio atque imas capiebant omnia sedes; / quae quanto magis inter se perplexa coibant, / tam magis expressere ea quae mare sidera solem / lunamque efficerent et magni moenia mundi." Text and translation (slightly modified) from Rouse and Smith 1992, 412–413.

[46] Lucretius 5.457-470 and 498-501.

[47] See e.g. Cicero, *De natura deorum* 2.84, reporting the Stoic view: "in medium locum mundi, qui est infimus."

Lucretius' anti-Stoic polemic must postdate Epicurus.[48] In that case Lucretius' refutation can be seen as a defence of the orthodox Epicurean position against a challenge that Epicurus himself will not have been aware of. That the passage should be a later addition to Epicurus' argumentation even seems to be borne out by the order of Lucretius' account: without any prior reference to the Stoic alternative Lucretius first emphatically concludes that "there is need of an infinite quantity of matter on all sides,"[49] and only then sets out to refute the rival theory which threatens to undermine this conclusion.

The second passage (5.449-508), by contrast, is hard to reconcile with the orthodox Epicurean view. Whereas Epicurus himself endorses a *parallel* conception of downward motion, to which Lucretius generally also subscribes, this passage assumes a *centripetal* downward tendency. Moreover, the account finds no parallel in any other known Epicurean writing. The only parallel passage is found in Aëtius' *Placita* 1.4, where a very similar theory is reported without attribution.[50] Yet the explicit reference to atoms and to the non-providential nature of the world's coming-into-being make it clear that the account must be atomistic. Moreover, certain details – weight difference rather than a vortex as the formative principle, and the tenuous rather than heavy nature of the heavenly bodies – clearly place the account on the Epicurean rather than the Democritean side.[51] In fact, the theory is Epicurean in every respect other than the assumption of a centripetal instead of parallel gravity. And yet, precisely this assumption makes the theory anomalous within the framework of orthodox Epicurean cosmology, and virtually irreconcilable with the infinity of atoms and worlds.

3.2.5 Provisional Conclusion

While in the *Letter to Herodotus* Epicurus could still confidently claim to have proved, once and for all, the joint infinity of space and bodies, the subsequent appearance of an alternative theory which allowed for a finite amount of matter to remain together in infinite space posed a challenge which later Epicureans had to meet. In Lucretius' *De rerum natura* we find an attempt to refute this rival theory and re-establish the orthodox Epicurean position, which in the rest of his work is simply taken for granted. As we have seen, however, Lucretius' refutation is not entirely convincing. The question arises, therefore, why Lucretius, like most other Epicureans, chose to stick to the orthodox view. An answer may be found in the important consequences of this view, especially with respect to Epicurean theology.

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[48] For the early Epicureans' lack of engagement with Stoic philosophy see Sedley 1998, 73, and especially Kechagia 2010.

[49] Lucretius 1.1051: "infinita opus est vis undique materiai." Text and translation from Rouse and Smith 1992, 86–87.

[50] For a comparison of Lucretius' and Aëtius' cosmogonical accounts, see Bakker 2016, 224–227.

[51] Spoerri 1959, 8–29; Bakker 2016, 226–227.

3.3 Theological Consequences of the Infinity of the Universe

The infinity of the universe and its two component parts appears to have some remarkable consequences. Firstly, it spawns an infinity of other worlds beside the one we inhabit; secondly, it makes the spontaneous coming-into-being of a world not merely possible but necessary; and, finally, it allows for the simultaneous truth of multiple, even mutually incompatible, explanations. What is more, all these corollaries have been argued by Epicurus himself or by his modern interpreters to be crucial, in one way or another, to the Epicurean mission to free the world from divine intervention. If it can be shown that they are, indeed, crucial, this might explain why the Epicureans were so committed to the infinity of the universe, and had to defend this view against rival theories.

In the following part I will discuss each of these corollaries of the infinity of space and bodies, with special attention to their theological aspects. First, however, it will be expedient to give some account of the Epicurean concept of divinity, to serve as a background for the following discussion of infinity.

3.3.1 The Epicurean Concept of Divinity

The most important thing to know about the gods, according to Epicurus, is that they are not involved in the creation and administration of the world or any of its parts in any way. This does not mean that they do not exist, for we do have a preconception of them – a preconceived notion resulting from repeated impressions, such as occur to us in dreams.[52] This preconception not only tells us that the gods exist, but also that they are immortal and blissful.[53] And since, being perfectly blissful, the gods have neither need nor care for anything besides themselves, any involvement on their part in the creation and governance of the world or any part thereof must be rejected.[54]

In addition to this conceptual proof of the gods' inactivity with respect to the world, the Epicureans also had a store of empirical arguments to bolster their view. Since the opposite view was often supported by some form of the argument from design, in which the observation of functional and orderly structures in the world led to the assumption of a grand design and hence a designer god, the Epicureans could simply point to the many instances of disorderly and useless, or even harmful, things and phenomena in order to disprove the idea of such a grand design.[55] To the

[52] Cicero, *De natura deorum* 1.43–44; Epicurus, *Letter to Menoeceus* 123–124. For gods appearing in dreams see Lucretius 5.1169-1171

[53] Cicero, *De natura deorum* 1.45; Epicurus, *Letter to Menoeceus* 123–124. Cf. Lucretius 5.1175-1182.

[54] Epicurus, *Letter to Herodotus* 76 and 81; idem, *Letter to Pythocles*, 97; Cicero, *De natura deorum* 1.51-53; Lucretius 5.156-173

[55] Lucretius 5.195-234. Cf. Diogenes of Oenoanda "Theological *Physics*-sequence" (= NF 167 + NF 126/127 + fr. 20 + NF 182), cols. XIV-XVI, in Hammerstaedt and Smith 2014, 263–270.

Epicureans it was evident, therefore, that the gods neither created nor took care of the world or any of its parts or inhabitants.

It is with this view of the gods in mind that we will now look into some corollaries of the infinity of bodies and space.

3.3.2 Infinite Worlds and the Demiurge

One consequence of the infinity of atoms is the existence of not just a plurality, but even an infinity of worlds. In *Letter to Herodotus* 45, Epicurus writes:

> Furthermore, there are infinite worlds both like and unlike this world of ours. For the atoms being infinite in number, as was proved already, are borne on far out into space. For those atoms, which are of such nature that a world could be created out of them or made by them, have not been used up either on one world or on a limited number of worlds, nor again on all the worlds which are alike, or on those which are different from these. So that there nowhere exists an obstacle to the infinite number of the worlds.[56]

In this passage Epicurus seems to take on Plato, who in *Timaeus* 32c-d states that the composition of our world used up all the elements, leaving nothing outside, and in *Timaeus* 55c-d, conceding that there might be more than one world – say, five – still emphatically rejects the notion that there might be infinitely many.[57]

Epicurus' statement is repeated by Lucretius, *De rerum natura* 2.1048-1066, who then adds the following argument:

> Besides, when abundant matter is ready, when space is to hand, and no thing and no cause hinders, things must assuredly be done and completed. And if there is at this moment both so great store of seeds as all the time of living existence could not suffice to tell, and if the same power and the same nature abides, able to throw the seeds of things together in any place in the same way as they have been thrown together into this place, then you are bound to confess that there are other worlds in other regions and different races of men and generations of wild beasts.[58]

If the atoms were able to form a cosmos in this part of the universe they must have been able to do so elsewhere, and given the infinity of the universe, a possibility

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[56] Epicurus, *Letter to Herodotus* 45: Ἀλλὰ μὴν καὶ κόσμοι ἄπειροί εἰσιν, οἵ θ' ὅμοιοι τούτῳ καὶ Ἀνόμοιοι. αἵ τε γὰρ ἄτομοι ἄπειροι οὖσαι, ὡς ἄρτι Ἀπεδείχθη, φέρονται καὶ πορρώτατω· οὐ γὰρ καταν ήλωνται αἱ τοιαῦται ἄτομοι, ἐξ ὧν ἂν γένοιτο κόσμος ἢ ὑφ' ὧν ἂν ποιηθείη, οὔτ' εἰς ἕνα οὔτ' εἰς πεπερασμένους, οὔθ' ὅσοι τοιοῦτοι οὔθ' ὅσοι διάφοροι τούτοις. ὥστε οὐδὲν τὸ ἐμποδοστατῆσόν ἐστι πρὸς τὴν Ἀπειρίαν τῶν κόσμων. Translation in Bailey 1926, 25.

[57] See also Plato, *Timaeus* 31a–b.

[58] Lucretius 2.1067-1076: "Praeterea cum materies est multa parata, / cum locus est praesto, nec res nec causa moratur / ulla, geri debent nimirum et confieri res. / nunc et seminibus si tanta est copia quantam / enumerare aetas animantum non queat omnis, / visque eadem et natura manet, quae semina rerum / conicere in loca quaeque queat simili ratione / atque huc sunt coniecta, necesse est confiteare / esse alios aliis terrarum in partibus orbis / et varias hominum gentis et saecla ferarum." Text and translation in Rouse and Smith 1992, 178–179.

cannot fail to be realised, and not once, but infinitely many times. Hence there must be an infinity of worlds.

Lucretius' conclusion rests upon the application of two principles: *the principle of uniformity*, which assumes that the same circumstances obtain always and everywhere,[59] and a version of the so-called *principle of plenitude*, which states that whatever can be done, will be done at some time or place.[60]

Having concluded that there are infinitely many worlds, Lucretius proceeds to use this conclusion as a premise in his argument against the notion of a divinely governed universe:

> If you hold fast to these convictions, nature is seen to be free at once and rid of proud masters, herself doing all by herself of her own accord, without the help of the gods. For I appeal to the holy hearts of the gods, which in tranquil peace pass untroubled days and a life serene: who is strong enough to rule the sum of the immeasurable, who to hold in hand and control the mighty bridle of the unfathomable? who to turn about all the heavens at one time and warm the fruitful worlds with ethereal fires, or to be present in all places and at all times[.][61]

Lucretius' conclusion takes the form of a series of rhetorical questions which invite the answer 'nobody': nobody is strong enough to rule and control an infinite number of worlds, and nobody is able to be present always and everywhere throughout the infinite expanse of time and space.

However, as James Warren notes, this is not a particularly strong argument.[62] Several responses come to mind that would avoid Lucretius' desired conclusion that infinite worlds rule out divine intervention.

It might be suggested, for instance, that each world is governed individually by its own god. In Lucretius' defence, David Sedley points out that even those of Lucretius' opponents who were willing to assume a plurality of gods still assumed a single overall command by a supreme deity, and would thus, after all, be subject to Lucretius' implied criticism.[63]

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[59] See e.g. Darling 2016, 416, and Mash 1993, 209, who explicitly identifies 'uniformitarianism' as one of the assumptions underlying the Lucretian argument.

[60] The 'Principle of Plenitude' was first described by Lovejoy 1936, 52 *et passim*. For the attribution of this principle to the ancient atomists see e.g. Dick 1996, 12–13; Fowler 2002, 368–369; Sedley 2007, 138; 2013, ch. 4 (ad 5.416-770); Darling 2016, 329; and Bakker 2016, 21–24, 28–31, 74, 210. Versions of Lucretius' argument – e.g. Drake's Equation – are still invoked today by those arguing for the likely existence of extra-terrestrial life and intelligence: see e.g. Mash 1993, and Darling 2016, 329. For Bruno's application of the principle see Section 8.2 of Granada's Chapter 8 in this volume.

[61] Lucretius 2.1090–1099: "Quae bene cognita si teneas, natura videtur / libera continuo, dominis privata superbis, / ipsa sua per se sponte omnia dis agere expers. / nam pro sancta deum tranquilla pectora pace, / quae placidum degunt aevom vitamque serenam, / quis regere immensi summam, quis habere profundi / indu manu validas potis est moderanter habenas, / quis pariter caelos omnis convertere et omnis / ignibus aetheriis terras suffire feracis, / omnibus inve locis esse omni tempore praesto." Text and translation in Rouse and Smith 1992, 178–181.

[62] Warren 2004, 363–364. See also Sedley's critical response in Sedley 2007, 148–149.

[63] Sedley 2007, 149 n33, cites Xenophon, *Memorabilia* 4.3.13, where "he who organizes and holds together the whole world" (my translation) is singled out over the other gods. One might also think

One might also respond that god is, in fact, strong enough to rule the infinite. In Lucretius' defence, David Sedley points out that this would imply an infinitely extended god, a view which the Epicureans attributed to certain Presocratic philosophers, and which they strongly opposed, on the grounds that this would make it impossible for god to experience sensation, due to the lack of bodily extremities to sense with.[64] Perhaps, however, we do not even need to suppose that such a criticism was implied. Lucretius' most obvious opponents in the present context are not the Presocratics, but thinkers like Plato and the Stoics, who equated infinity with indeterminacy and imperfection, which have no place in divine creation[65]; and who therefore emphasized the limited and finite nature of the created world.[66] It was not until the third century A.D. that, among Neoplatonists and Christians, infinity began to be seen as perfection and a fitting attribute for a god.[67]

In short, Lucretius' argument is aimed at thinkers who not only believe in a divine involvement with the universe, but also think that this involvement needs to be a unified and limited affair.

Although, at first sight, this assumption seems to rescue Lucretius' anti-interventionist argument from such responses as were suggested above, it actually undermines his argument even further. Lucretius' argument is based on the infinity of worlds, a theory which in turn relies, among other things, on the application of *the principle of uniformity* – the assumption that the same circumstances apply everywhere. The validity of this assumption may be obvious if one adopts the Epicurean view of a universe filled with atoms that all obey the same physical laws, and hence may be assumed to produce the same effects everywhere. If, on the other hand, one adopts the theory that the world is created by a supreme deity, and that this act of creation is necessarily both unique and limited, it is clear that this result cannot be applied universally: even in an infinite universe filled with infinite matter the creation of one cosmos in no way implies the creation of another, let alone of an

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of Plato's *Timaeus* 40a–d, where the lesser, created gods are said to partake in the creation of the world at the Demiurge's behest. In fact, several centuries after Epicurus, in the second century AD, the Platonist Plutarch, conceding that there might, in fact, be more than one world (though not infinitely many), suggests that while each world might be governed by its own supreme deity, all the worlds together would still be subject to the single rule and reason of one divine overlord (Plutarch, *De defectu oraculorum* 29, 425f2 – 426b1).

[64] Sedley 2007, 149, citing the Epicurean arguments reported by Cicero in *De natura deorum* 1.26–28.

[65] On Plato see Clarke 1994, 70–72, who specifically quotes Plato's *Philebus* 16–18, 23c–30, 61–67; *Statesman* 283b–285a; *Laws* 716c; *Sophist* 265e. For Plato's application of the notion of limit to the creation of the world see Plato *Timaeus* 31a-b, 32c-33a, 55c-d. For the Stoics, see Plutarch, *De communibus notitiis* 30, 1074b7-c3 (*SVF* II 525, p. 167.28 – 168.1), which links infinity to indeterminacy, incompletion and disorderliness; Sextus Empiricus, *Against the Professors* 9.148–149, which rehearses a Stoic argument for the limited nature of the divine; and Cleomedes 1.1, 7–17 (*SVF* II 534), which emphasises the limited nature of the created world.

[66] Even Plutarch, while admitting a plurality of worlds (see n63 above), still stresses the finitude of nature (Plutarch, *De defectu oraculorum* 24, 423c7-11 and 25, 424a8-12) and god (ibid. 30, 426d8-10).

[67] Clarke 1994, 75–79.

infinite number of others.[68] Therefore, Lucretius' argument against divine intervention will convince only those who are already convinced that worlds do not come about due to divine intervention.

3.3.3 Chance and the Power of Infinity

What the Epicureans had to do, therefore, was to show that the world could have come into being even without divine intervention, as a result of mere chance. Now, that such an orderly and complex structure as our world should arise by chance seems exceedingly unlikely. The odds are dramatically increased, however, if infinity is brought into play: according to the principle of plenitude, given infinite opportunity, everything that is possible must be realised. Accordingly, even without divine intervention, the infinity of the universe makes the coming-into-being of a world like ours not only possible but even inevitable.[69]

However, as James Warren notes, for this conclusion to obtain the Epicureans did not have to postulate the infinity of matter and space; the infinity of time alone, which the Epicureans commonly accepted, would suffice to guarantee that any possible configuration would be realized, and not once, but infinitely many times.[70]

What is more, in the two passages where Lucretius actually applies the principle of plenitude to the formation of the cosmos (1.1021–1028 and 5.419–431), he only refers to the infinity of time, not of matter and space. I quote the second passage, which is the clearest in this respect:

> For certainly it was no design of the first-beginnings that led them to place themselves each in its own order with keen intelligence, nor assuredly did they make any bargain what motions each should produce; but because many first-beginnings of things in many ways, struck with blows and carried along by their own weight *from infinite time up to the present*, have been accustomed to move and to meet in all manner of ways, and to try all combinations, whatsoever they could produce by coming together, for this reason it comes to pass that being spread abroad *through a vast time*, by attempting every sort of combination and motion, *at length* those come together which, being suddenly brought together, often become the beginnings of great things, of earth and sea and sky and the generation of living creatures.[71]

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[68] So also Asmis 1984, 66 n19: "a demiurge would provide a reason why the number of possibilities should be restricted to a single possibility."

[69] For a lucid and very attractive exposition of this theory, see Sedley 2007, 137–139 and 155–166.

[70] Warren 2004, 364, citing David Hume's *Dialogues Concerning Natural Religion*, part 8. For the Epicureans' implicit endorsement of the infinity of time see Sedley 1999, 373.

[71] Lucretius 5.419-431: "nam certe neque consilio primordia rerum / ordine se suo quaeque sagaci mente locarunt / nec quos quaeque darent motus pepigere profecto, / sed quia multa modis multis primordia rerum / *ex infinito iam tempore* percita plagis / ponderibusque suis consuerunt concita ferri / omnimodisque coire atque omnia pertemptare, / quaecumque inter se possent congressa creare, / propterea fit uti *magnum* volgata *per aevom*, / omne genus coetus et motus experiundo, / *tandem* conveniant ea quae convecta repente / magnarum rerum fiunt exordia saepe, / terrai maris et caeli generisque animantum." Text and translation in Rouse and Smith 1992, 410–413 (my emphasis).

The same observation applies to Epicurus as well, who, according to one ancient testimony, stated that "nothing unfamiliar comes about in the universe, due to the infinity of time that has already passed."[72]

In short, although it is often stated that the infinity of the universe was a necessary part of the Epicureans' anti-teleological argument, the argument actually works just as well on the assumption of infinite time, and was, in fact, applied in this way by Lucretius and Epicurus themselves.

3.3.4 Infinity and the Truth of Multiple Explanations

The Epicurean theory of infinite worlds also carries important epistemological consequences. In astronomical and meteorological matters the Epicureans famously prescribed the use of multiple explanations to account for each phenomenon, instead of just one.[73] This might just be considered a kind of epistemic modesty: since in such matters the evidence does not allow us to discriminate between various explanations, all explanations that agree with the observations and do not violate the general principles of Epicurean physics must be retained. However, there is ample evidence that the Epicureans went beyond a mere sceptical affirmation of doubt. They did not doubt which of the accepted explanations was true: they were adamant that *all* accepted explanations – even mutually incompatible ones – were true.[74]

But how could the Epicureans assert the simultaneous truth of multiple explanations? Lucretius offers the following argument (*DRN* 5.526-533):

> For which of these causes holds in our world it is difficult to say for certain; but what may be done and is done through the whole universe in the various worlds made in various ways, that is what I teach, proceeding to set forth several causes which may account for the movements of the stars throughout the whole universe; one of which, however, must be that which gives force to the movement of the signs in our world also; but which may be the true one, is not his to lay down who proceeds step by step.[75]

There may be doubt as to which cause is operative in our world, but this does not mean that other explanations are not true: in the infinity of the universe every possible explanation must be actualized somewhere, and in this sense every possible

[72] Epicurus fr. 266 (in Usener 1887, 191) = ps.-Plutarch, *Stromateis* 8: οὐδὲν ξένον ἐν τῷ παντὶ Ἀποτελεῖται παρὰ τὸν ἤδη γεγενημένον χρόνον ἄπειρον (translation mine).

[73] For an overview see e.g. Taub 2009, 110–112, 115, 120–123.

[74] On the truth of multiple explanations see Striker 1974; Sedley 1982, 263–272; Asmis 1984, 178–180, 193–196, 211, 321–336; Long and Sedley 1987a, 90–97; Asmis 1999, 285–294; Allen 2001, 194–205 and 239–241; Bénatouïl 2003, 42–44; Verde 2013, 134–135; Bakker 2016, 13–31.

[75] Lucretius 5.526–533: "Nam quid in hoc mundo sit eorum ponere certum / difficile est; sed quid possit fiatque per omne / in variis mundis varia ratione creatis, / id doceo, plurisque sequor disponere causas, / motibus astrorum quae possint esse per omne; / e quibus una tamen siet hic quoque causa necessest / quae vegeat motum signis; sed quae sit earum / praecipere haudquaquamst pedetemptim progredientis." Text and translation from Rouse and Smith 1992, 418–419.

explanation is also true. This is yet another application of the principle of plenitude.

This method of multiple explanations was the Epicureans' response to the dogmatic certainty with which other philosophers propounded single explanations. A sceptic detachment would not do, because this would leave open the possibility that the other philosophers were right after all. The Epicureans therefore countered the dogmatic assertion of single explanations with an equally dogmatic assertion of a multiple account.[76]

But why would the Epicureans want to oppose single explanations in the first place? As Epicurus himself repeatedly states, the principal reason for engaging in physical inquiry is to exclude the divine from the workings of nature, see e.g. Epicurus' *Letter to Herodotus* 76–77:

> Furthermore, the motions of the heavenly bodies and their turnings and eclipses and risings and settings, and kindred phenomena to these, must not be thought to be due to any being who controls and ordains or has ordained them and at the same time enjoys perfect bliss together with immortality (for trouble and care and anger and kindness are not consistent with a life of blessedness, but these things come to pass where there is weakness and fear and dependence on neighbours).[77]

Elsewhere, too, Epicurus enjoins his reader not to resort to myth.[78] However, if physical inquiry is all about excluding myth and divine intervention, why is one naturalistic explanation not enough?[79] The answer to this question may be found in a number of passages in Epicurus' *Letter to Pythocles*. In §87, for instance, Epicurus writes:

> But whenever one accepts one explanation while rejecting another that harmonizes just as well with the phenomenon, it is clear that one falls from scientific inquiry altogether and is plunged into myth.[80]

According to Epicurus, providing a single explanation when other explanations are equally plausible is in itself a kind of myth. But why should a single explanation amount to myth? Another relevant passage that may provide some further clues is §113:

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[76] See Warren 2004, 361: "With the addition of the conception of infinite *kosmoi* the Epicureans can claim not only that one of the possible explanations is the true one but that in fact all of them are true. In this way they can hope to bridge the gap between offering multiple merely possible explanations and the provision of sure, tranquillity-producing, conviction."

[77] Epicurus, *Letter to Herodotus* 76–77: Καὶ μὴν ἐν τοῖς μετεώροις φορὰν καὶ τροπὴν καὶ ἔκλειψιν καὶ Ἀνατολὴν καὶ δύσιν καὶ τὰ σύστοιχα τούτοις μήτε λειτουργοῦντός τινος νομίζειν δεῖ γίνεσθαι καὶ διατάττοντος ἢ διατάξαντος καὶ ἅμα τὴν πᾶσαν μακαριότητα ἔχοντος μετὰ Ἀφθαρσίας· οὐ γὰρ συμφωνοῦσι πραγματεῖαι καὶ φροντίδες καὶ ὀργαὶ καὶ χάριτες μακαριότητι, Ἀλλ' ἐν Ἀσθενείᾳ καὶ φόβῳ καὶ προσδεήσει τῶν πλησίον ταῦτα γίνεται. Translation in Bailey 1926, 49.

[78] Epicurus, *Letter to Pythocles* 104.3: μόνον ὁ μῦθος Ἀπέστω. Cf. ibid. 115.8.

[79] Similarly Verde 2013, 130.

[80] Epicurus, *Letter to Pythocles* 87: ὅταν δέ τις τὸ μὲν Ἀπολίπῃ τὸ δὲ ἐκβάλῃ ὁμοίως σύμφωνον ὂν τῷ φαινομένῳ, δῆλον ὅτι καὶ ἐκ παντὸς ἐκπίπτει φυσιολογήματος, ἐπὶ δὲ τὸν μῦθον καταρρεῖ. Translation mine.

> But to assign a single cause for these phenomena, when the phenomena call for a plural account, is madness, and is unfittingly practised by those who are devoted to idle astronomy and vainly assign causes for certain phenomena, *since* (ὅταν) they do not free divine nature in any way from the burden of responsibilities.[81]

Providing single explanations for celestial phenomena is typically practised by devotees of astronomy – not just professional astronomers, but also those who accepted and incorporated the astronomers' findings into their own cosmologies, like Plato, Aristotle and the Stoics.[82] However, Epicurus' criticism is not limited to these devotees of astronomy, but also applies to others who provide single explanations when the phenomena call for several, whether one is dealing with astronomical or atmospheric occurrences. Nor should the explanations provided by these devotees of astronomy and other proponents of single causes be spurned as such: this is made clear by the inclusion of many such views in Epicurus' and Lucretius' lists of multiple explanations.[83] Apparently these views are only objectionable in so far as they are claimed to be uniquely true. But why would this be objectionable? The answer to this question is given in the concluding, subordinate clause of the cited passage. Unfortunately, the Greek here presents an ambiguity. According to Liddell and Scott's *Greek-English Lexicon*, ὅταν, the conjunction which starts the clause, normally means "*whenever*, with a conditional force."[84] Yet if the conjunction is taken in this sense, one might conclude that assigning single causes is okay after all, as long as the gods are not involved. This would be a very weak conclusion after Epicurus' insistence on the need for multiple explanations both in the present passage and throughout the *Letter to Pythocles*, and would also be at odds with the previously quoted passage (from §87), where rashly opting for a single explanation (apparently regardless of its content) was equated to myth. However, Liddell and Scott also report a second meaning. Occasionally, ὅταν is also used in a causal sense (attested from Aristotle onwards), which may be rendered as 'since.'[85] If we take the conjunction in this sense, the final clause turns out to provide the very answer we were looking for: assigning single causes, when the phenomena call for several, is wrong, because this would imply divine involvement in the world. This conclusion seems to be confirmed by §97:

> And divine nature must not be applied to these things in any way, but must be preserved unburdened by responsibilities and in complete blessedness. For if this practice is not observed the entire inquiry into the causes of celestial phenomena will be idle, as it has already been for certain people who have not clung to the possible method, but have fallen back into idle talk by believing that things only happen in one way, and rejecting all other

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[81] Epicurus, *Letter to Pythocles* 113: τὸ δὲ μίαν αἰτίαν τούτων Ἀποδιδόναι, πλεοναχῶς τῶν φαινομένων ἐκκαλουμένων, μανικὸν καὶ οὐ καθηκόντως πραττόμενον ὑπὸ τῶν τὴν ματαίαν Ἀστρολογίαν ἐζηλωκότων καὶ εἰς τὸ κενὸν αἰτίας τινῶν Ἀποδιδόντων, ὅταν τὴν θείαν φύσιν μηθαμῇ λειτουργιῶν Ἀπολύωσι. Translation (and emphasis) mine.

[82] See Bakker 2016, 57.

[83] For the incorporation of the astronomers' views in Epicurus' and Lucretius' lists of alternative explanations, see Bakker 2016, 42–58.

[84] Liddell and Scott 1940, 1264, lemma ὅταν.

[85] Admittedly, the use of ὅταν in this sense is otherwise unattested in Epicurus' works.

> explanations that follow from the possible method, being driven thus to what is inconceivable, and unable to make a survey of the phenomena that must be accepted as signs.[86]

Although the statement is quite convoluted, it seems to imply that those "people who […] have fallen back into […] believing that things only happen in one way" have thereby failed to observe the practice of preserving divine nature "unburdened by responsibilities and in complete blessedness."

In short, according to Epicurus, assigning single explanations to celestial phenomena in itself (i.e. regardless of the content of each explanation) already amounts to involving the gods in the workings of nature. Why this should be so is not stated clearly anywhere by Epicurus. However, his explicit reference to the devotees of astronomy in §113 suggests that his quarrel is not so much with those who provide single causes on one or two occasions, but with those who do so systematically, like professional astronomers and their followers. Elsewhere I have argued, on the basis of the above and other passages, that Epicurus was opposed to the astronomers and their followers because of their groundless reliance on a preconceived theoretical model in which phenomena were accounted for with single explanations according to a unified explanatory principle.[87] It was the belief in these general explanatory theories, often illustrated by means of tangible mechanical models,[88] that Epicurus especially opposed, considering them to be nothing more than "empty assumptions and arbitrary principles,"[89] without a firm basis in the phenomena.

Moreover, by embracing these models the devotees of astronomy grant the world an amount of coherence and regularity that seems to point to an overall design.[90] In fact, both Plato and the Stoics explicitly link the orderly nature of the world, and especially the heavenly sphere, to its being designed by a god. In *Timaeus* 34b-40d, Plato describes how the Demiurge successively created the heavens, the celestial orbits, and finally the heavenly bodies themselves as living gods, according to a single coherent and intelligent plan, the details of which can only be understood by the use of visible models; and in *Laws* 820e-822c he prescribes the study of astronomy in order to eradicate the erroneous and blasphemous view that the planets, being gods, should wander about aimlessly. The Stoics even made the order and

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[86] Epicurus, *Letter to Pythocles* 97: καὶ ἡ θεία φύσις πρὸς ταῦτα μηδαμῇ προσαγέσθω, Ἀλλ' Ἀλειτούργητος διατηρείσθω καὶ ἐν τῇ πάσῃ μακαριότητι. ὡς εἰ τοῦτο μὴ πραχθήσεται ἅπασα ἡ τῶν μετεώρων αἰτιολογία ματαία ἔσται, καθάπερ τισὶν ἤδη ἐγένετο οὐ δυνατοῦ τρόπου ἐφαψαμένοις, εἰς δὲ τὸ μάταιον ἐκπεσοῦσι τῷ καθ' ἕνα τρόπον μόνον οἴεσθαι γίνεσθαι, τοὺς δ' ἄλλους πάντας τοὺς κατὰ τὸ ἐνδεχόμενον ἐκβάλλειν, εἵς τε τὸ Ἀδιανόητον φερομένους καὶ τὰ φαινόμενα ἃ δεῖ σημεῖα Ἀποδέχεσθαι μὴ δυναμένους συνθεωρεῖν. Translation mine.

[87] Bakker 2016, 32–33, 263, 266–267; see also 57–58.

[88] On the use of mechanical models in astronomy see Cornford 1935, 74–76; and Evans 1998, 78–84. On Epicurus' opposition to this practice see Sedley 1976, 32, 37–39.

[89] Epicurus, *Letter to Pythocles* 86: Οὐ γὰρ κατὰ Ἀξιώματα κενὰ καὶ νομοθεσίας φυσιολογητέον, Ἀλλ' ὡς τὰ φαινόμενα ἐκκαλεῖται. Translation in Bailey 1926, 59.

[90] Similarly Verde 2013, 131, 135.

regularity of the celestial motions a prime exhibit in their argument from design, likening the heavenly sphere to a man-made orrery.[91]

In this way the systematic application of *single* explanations could be taken to imply a belief in divine creation, to which the systematic and dogmatic assertion of *multiple* explanations would provide an effective antidote. However, in order to perform this function, each of these multiple explanations has to be not merely possible, but actually true. And this is where, as we have seen, the infinity of worlds comes in: the principle of plenitude stipulates that in the infinity of the universe every possible explanation must be true somewhere.

However, to this line of reasoning several objections can be made. Firstly, one might call into question whether single explanations really do imply divine governance. Epicurus may have believed so, but Lucretius, in those passages where he either expounds or applies the method of multiple explanations, never claims that multiple explanations as such are necessary to eliminate divine intervention. In fact, on several occasions where one might have expected a multiple account, Lucretius is content to give a single explanation, apparently without fearing thereby to make the gods responsible. A later Epicurean, Diogenes of Oenoanda, even gives up on the simultaneous truth of multiple explanations altogether, claiming instead that, "while all explanations are possible, this one is more plausible than that," without worrying about theological consequences.[92]

Secondly, even if one accepts that the dogmatic assertion of multiple explanations is necessary to rule out divine involvement, one might still doubt whether a plurality of worlds is required to guarantee the truth of each individual explanation. In a recent article Francesco Verde has suggested that Lucretius may not have rendered Epicurus' thought adequately in this respect.[93] While emphasizing – even more clearly than Epicurus himself – the truth of every given explanation in the universe at large, Lucretius at the same time seems to slip right back into the scepticism that Epicurus wanted to avoid, by stressing that in this world only one explanation applies, although we do not know which one. Since in similar contexts Epicurus himself never refers to other worlds, the various individual explanations should be thought of as true even within this world: compatible explanations could be true at the same time, while incompatible ones may still be true sequentially. If Verde is right, then however important the method of multiple explanations may have been to demythologize the world, the infinity of the universe may not have played any part in it.

[91] Cicero, *De natura deorum* II 88.

[92] Diogenes of Oenoanda fr.13 iii 10–12 (in Smith 1993, 171). For the epistemological import of this passage see Verde 2013, 136–137; Bakker 2016, 37–42, 242; Leone 2017, 97–100; and especially Corsi 2017, 277–282.

[93] Verde 2013, 139–141. See also Corsi 2017, 262–263.

3.3.5 Summary

Although the infinity of atoms, and consequently of worlds, appears as a premise in several actual or presumed Epicurean arguments against divine intervention, it turns out to be neither sufficient nor necessary to arrive at the desired conclusion. True, the infinity of worlds rules out divine intervention (at least as conceived by Plato and the Stoics), but this can only be established after divine intervention has been ruled out already. True, the joint infinity of atoms and void guarantees that any configuration of atoms, including our cosmos, will be realized even without divine intervention, but so does the infinity of time, and, in fact, the Epicureans only invoked the latter. True, the infinity of worlds would ensure that every objectively possible explanation is also true, as Lucretius claims; but it is debatable, firstly, to what extent Epicurus himself used or needed the infinity of worlds to account for the truth of multiple explanations; secondly, to what extent later Epicureans still endorsed the truth of multiple explanations, as opposed to their mere possibility or probability; and thirdly, to what extent later Epicureans were still committed to the thesis that divine intervention can only be eliminated by multiple, as opposed to single, naturalistic explanations. In sum, there is no reason to assume that the Epicureans had strong theological motives for positing and upholding the joint infinity of atoms and void.

3.4 Conclusion

In this chapter I have tried to establish why the Epicureans, in contrast to every other ancient school of philosophy, posited an infinite amount of matter. I have approached this question from two different angles. In the first half of the chapter the physical arguments for the infinity of matter were discussed. In both Epicurus' *Letter to Herodotus* and Lucretius' *De rerum natura* the infinite number of atoms is inferred from the infinity of space, on the assumption that a finite number of atoms would be scattered abroad and not be able to meet and produce anything. For Epicurus this was the end of the matter, but later Epicureans had to deal with a rival theory that threatened to undermine the Epicurean argument: by assuming a theory of centripetal gravity the Stoics were able to account for the infinity of space without the need for a corresponding infinity of matter. Lucretius offers a refutation of the Stoic view, but his counter-arguments appear to be either unfounded or unconvincing, and are further undermined by Lucretius' implicit endorsement, later on in his work, of centripetal gravity.

In the second half of the chapter I have looked at the question from another point of view. If the physical arguments are not strong enough to prove the infinity of atoms, the Epicureans may have had other – theological and ethical – motives to uphold this thesis. In the writings of Epicurus and Lucretius several arguments are found or are thought to be implied in which the infinity of matter rules out divine

intervention in the world. However, as we have just seen, none of these arguments holds up to scrutiny.

The somewhat disappointing conclusion is that the Epicurean endorsement of the infinity of matter, and hence of worlds, was warranted neither by physical nor by ethical considerations. Epicurus himself, blissfully ignorant of the challenge that would be posed by the Stoics, may still have believed that his proof of the infinity of atoms was conclusive, and hence could be used, perhaps not as sufficient, but at least as supporting evidence against divine intervention. Later Epicureans, however, felt obliged to defend a thesis that was neither consequent upon the principles of Epicurean physics, nor antecedent to the main doctrines of Epicurean ethics, but one that nevertheless had become a defining tenet of their sect.[94]

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[94] On the Epicureans' faithfulness to Epicurus' authority see Sedley 1989.

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